



U.S. Department
of Transportation
**Federal Aviation
Administration**

Advisory Circular

Subject: RTCA Document DO-160 versions D, E and F, “Environmental Conditions and Test Procedures for Airborne Equipment”

Date: 11/19/09

AC No: 21-16F

Initiated by: AIR-100

1. What is the purpose of this Advisory Circular?

a. This advisory circular (AC) identifies RTCA Document No. (RTCA/DO)-160 versions D, E, and F, *Environmental Conditions and Test Procedures for Airborne Equipment*, dated July 27, 1997, December 20, 2005, and December 6, 2007, respectively, as containing acceptable environmental qualifications to show compliance with certain airworthiness requirements. We, the FAA, strongly encourage the use of RTCA/DO-160F for new articles.

b. Appendix 1 of this AC provides a summary of the changes from RTCA/DO-160C to RTCA/DO-160D, version D to E, and version E to F. The information in the table will assist you in determining if a particular version of RTCA/DO-160 is acceptable.

Note: When reference to RTCA/DO-160D is made in this AC, it includes Changes 1, 2, and 3, dated December 14, 2000, June 12, 2001, and December 5, 2002, respectively.

c. This AC is not mandatory and does not constitute a regulation. This AC describes a means, but not the only means, to comply with airworthiness requirements.

2. To whom does this AC apply? This AC applies to manufacturers and installers that use RTCA/DO-160 for environmental qualifications of their airborne equipment.

3. Cancellation. This AC cancels AC 21-16E, *RTCA Document DO-160E, Environmental Conditions and Test Procedures for Airborne Equipment*, dated December 20, 2005.

4. What is RTCA/DO-160?

a. RTCA/DO-160 (or its precursor, RTCA/DO-138) has been used as a standard for environmental testing since 1958. It defines standard environmental test conditions (categories) and applicable test procedures for airborne equipment.

b. The tests in RTCA/DO-160 provide a laboratory means of demonstrating the performance characteristics of airborne equipment in environmental conditions that may be encountered in operation of the equipment in aircraft. It is not the intent of RTCA/DO-160 to be

used as a measure of service life of the airborne equipment subjected to these tests.

c. As the realities of equipment operation under actual environmental conditions are better understood and new needs arise within the aviation community, RTCA/DO-160 has been revised to address the emerging and improved test techniques. The categories that have been developed over time reflect a reasonably mature understanding as to the severity of the environmental stresses, the degrees of mitigation achievable in the design of an installation, and the robustness that must be designed into equipment in order to perform in the operating environment.

5. Related Documents.

- a. Title 14 of the Code of Federal Regulations, (14 CFR) parts 21, 23, 25, 27, 29, 33 and 35 are relevant to this AC.
- b. AC 20-136, *Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning*.
- c. AC 20-158, *The Certification of Aircraft Electrical and Electronic Systems for Operation in the High-Intensity Radiated Fields (HIRF) Environment*.
- d. AC 33.17-1, *Fire Prevention*.

6. Using RTCA/DO-160 for Technical Standard Orders (TSOs).

a. If you are an applicant seeking a TSO authorization for airborne equipment, you may request a deviation, in accordance with the requirements of 14 CFR § 21.609, to use the conditions and procedures in a different version of RTCA/DO-160 instead of the corresponding conditions and procedures specified in the applicable TSO. Although an applicant may request to use an earlier version, we recommend that you use RTCA/DO-160F.

b. The table in Appendix 1 of this AC provides sufficient data for an applicant to use as a comparison between RTCA/DO-160D, E, and F. The FAA has determined that versions D, E and F provide an equivalent level of safety when the applicable version is identified in the Environmental Qualification Form (EQF). If the installed electrical/electronic equipment must meet lightning requirements use RTCA/DO-160D or later per the latest revision of AC 20-136. However, if the installed equipment is expected to be subject to HIRF requirements in 14 CFR §§ 23.1308, 25.1317, 27.1317, or 29.1317, use RTCA/DO-160F. RTCA/DO-160E is also acceptable to meet the HIRF requirements for level B and C systems when using test levels defined in the appropriate regulations as discussed in AC 20-158.

c. If the version of RTCA/DO-160 specified in a TSO is version D or later, and an applicant wishes to use a version prior to RTCA/DO-160D, then the applicant must still apply for a deviation as discussed in paragraph 6a. However, instead of using Appendix 1 as referenced in paragraph 6b, the applicant must compare the specific procedure and category changes, section by section, between the two versions of RTCA/DO-160 and address the differences between the two test results when providing an equivalent level of safety.

d. When a new application is based on the design of an existing approved article, the applicant may ask to use environmental test data from the existing article's environmental qualification, based on similarity between the two articles. This request must be fully supported with a detailed similarity assessment comparing the changes from the earlier approved article to the article in the new application. The ACO may accept the data if the similarity assessment clearly shows that the design changes will not adversely affect the environmental qualification.

7. Using RTCA/DO-160 for Installers.

a. If you are an applicant installing equipment, you may use RTCA/DO-160, any version, to support compliance with the appropriate airworthiness requirements. When possible, we recommend that you use RTCA/DO-160F as it provides the most clear and complete test procedures.

b. Use the EQF provided by the equipment manufacturer to compare against your specific installation requirements. The EQF provides information regarding which version of DO-160 was used, which environmental tests were conducted and the environmental category of the equipment being tested. If the EQF categories do not adequately address your installation, then you or the equipment manufacturer may need to re-qualify the equipment to meet the appropriate sections and category levels.

c. When installing equipment previously qualified to other environmental standards, such as Military Standard (MIL-STD) 810C, the equipment must comply with applicable airworthiness requirements. You may use DO-160F to do a comparison analysis to show that it provides an equivalent level of safety in the expected operating environment.

d. When a new application is based on the design of an existing approved article, the applicant may ask to use environmental test data from the existing article's environmental qualification, based on similarity between the two articles. This request must be fully supported with a detailed similarity assessment comparing the changes from the earlier approved article to the article in the new application. The ACO may accept the data if the similarity assessment clearly shows that the design changes will not adversely affect the environmental qualification.

e. Some of the environmental conditions and test procedures contained in RTCA/DO-160 such as waterproofness, sand and dust, or salt fog, may not be applicable to your installation based on intended location of the equipment. You must determine which sections and categories are applicable to your specific project.

f. When the equipment installation is required to meet HIRF requirements in 14 CFR §§ 23.1308, 25.1317, 27.1317, or 29.1317 use RTCA/DO-160F. RTCA/DO-160E is also acceptable to meet the HIRF requirements for level B and C systems when using test levels defined in the appropriate regulations as discussed in AC 20-158. For additional guidance on HIRF refer to the latest revision of AC 20-158.

g. When the electrical/electronic equipment installations are required to meet lightning requirements use RTCA/DO-160D or later. For additional guidance on lightning refer to the latest revision of AC 20-136.

h. RTCA/DO-160, Section 26, *Fire, Flammability*, is not sufficient for 14 CFR parts 25 and 33. Fire and flammability guidance for 14 CFR part 25 is provided in 14 CFR part 25 Appendix F. For 14 CFR part 33, please refer to the latest revision of AC 33.17-1.

8. How To Get Related Documents.

a. Order copies of RTCA documents from RTCA, Inc, 1828 L Street, NW, Suite 805, Washington, DC 20036-4007, telephone (202) 833-9339, fax (202) 833-9434. You can also order copies online at <http://www.rtca.org>.

b. Order copies of 14 CFR parts from the Superintendent of Documents, Government Printing Office, P.O. Box 979050, St. Louis, MO, 63197. For general information, telephone (202) 512-1800 or fax (202) 512-2250. You can order copies from the Government Printing Office website at www.access.gpo.gov. Select "Access" then "Online Bookstore." Select "Aviation," then "Code of Federal Regulations."

c. View a list of all Advisory Circulars on the FAA's Aviation Safety Information Management System (AVSIMS) at www.faa.gov/regulations_policies/advisory_circulars/ or from the FAA website: www.faa.gov. Order copies of ACs from the U.S. Department of Transportation, Subsequent Distribution Office, M-30, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785.



Susan J. M. Cabler
Assistant Manager, Aircraft Engineering
Division

Appendix 1
Summary of changes between DO-160D, E, and F

RTCA/DO-160 will continue to be subject to revisions as needs arise in the aviation community. However, it is not always feasible for an applicant to use the more current revision. The following table is a summary of the changes made from RTCA/DO-160C to D, D to E, and E to F. Versions of RTCA/DO-160 prior to RTCA/DO-160D are also not included in this table. The information in the table should help you determine if your new article should be subject to a particular version of RTCA/DO-160.

| DO-160 Sections | Changes from DO-160C to DO-160D ¹ | Changes from DO-160D ¹ to DO-160E | Changes from DO-160E to DO-160F |
|--|---|---|---|
| Section 1-Section 3: Purpose and Applicability, Definitions of Terms, and Conditions of Tests | Editorial and clarifications changes only. | Section 3: The requirement for cumulative testing of Temperature, Altitude, Humidity, and Vibration was removed, and clarification was added with respect to the use of multiple test articles. | Added section 2.9, <i>Applicability of Test Results</i> and section 3.9, <i>EUT Configuration for Susceptibility Tests</i> . |
| Section 4: Temperature and Altitude | <i>Section 4.3 Equipment Categories</i> added reference categories for in-flight loss of cooling test. | <i>Section 4.5 Temperature Test</i> was restructured to include sub-section 4.5.2 Operating Low Temperature. | <i>Section 4.5.3 Ground Survival High Temperature Test and Short Term Operating High Temperature Test</i> clarified soak time upon reaching short time operating low and high temperature. <i>Section 4.5.5, In-Flight Loss of Cooling Test</i> in the note clarified cooling source and power. |
| Section 5: Temperature Variation | <i>Section 5.3 Test Procedures</i> was revised to provide provisions for collecting data during a single cycle of test and reduced data collection under certain test conditions. | <i>Section 5.2 Temperature Change Rates</i> added two temperature shock tests, categories S1 and S2, and Sections 5.3.2 and 5.3.3 are the tests sections that accompany the newly added categories, respectively. | Sections, 5.3.1h, 5.3.2h, and 5.3.3i, changed the performance compliance timing to be in the second, or last cycle. |

¹ Includes Changes 1, 2, and 3 to RTCA/DO-160D.

| DO-160 Sections | Changes from DO-160C to DO-160D ¹ | Changes from DO-160D ¹ to DO-160E | Changes from DO-160E to DO-160F |
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| Section 6: Humidity | Editorial changes were made to eliminate redundant description of the test procedures. Velocity of air throughout the exposure area changed from “Shall not exceed 0.75 m/s” to “Between 0.5 and 1.7 m/s”. Alternative method was added to measure the water pH. | Section 6.3 was modified to allow a ± 4 percent tolerance to the relative humidity requirement. | In paragraphs 6.3.1, 6.3.2, and 6.3.3 changed step 2 to 38 degrees to agree with corresponding figure. |
| Section 7: Operational Shocks and Crash Safety | Equipment category definitions were added for fixed wing and helicopter installations. Crash Safety levels were identified for helicopters (20g) and increased for fixed wing crash safety levels (20g). Shock pulse was changed from half sine to saw tooth. Half-sine shock pulse curve changed to reflect saw-tooth profile. Test levels were changed from DO-160C based on empirical data. | Fixed wing and helicopter operational and crash safety test requirements were made the same. | Category definitions were revised for clarification. Text description and centrifuge definitions were revised in section 7.3.3 and figure 7.3, respectively, to reflect the correct setup direction for acceleration load. |
| Section 8: Vibration | New section defining vibration requirements for helicopters was added. Random vibration levels were changed by the addition of new curves. Tables and figures were modified to support changes in test levels. | Fixed Wing Zone 2 features two new test curves. High Level Short Duration Category Test was revised. Helicopter endurance test times were reduced and the unknown helicopter test procedure was reconfigured (Category U). Unknown helicopter test procedure (Category U2) was added as an alternative to revision D. | Performance test times were reduced from 30 minutes to a minimum of 10 minutes. Robust test equipment operating, not operating requirements were standardized to have equipment not operating during sinusoidal scans and operating during the robust test portion of the test, unless specified otherwise by the applicable equipment specifications. |
| Section 9: Explosion Proofness | Fuel mixture calculation was corrected for hexane explosive proofness test. Atmospheric test pressure requirements were clarified. | Minor changes were made in the procedure to improve repeatability. | Environment definition and category definitions were revised. Reference to 100/130 octane fuel was deleted from figure 9-4. |
| Section 10: Waterproofness | Test step that verifies absence of water penetration into test unit following test was deleted because it was not consistent with intent and purpose of test. The test is intended to verify performance of unit | Minor improvements to pre-heat unit and to reduce risk of thermal shock were made. | Drip Rate was changed from 280 l/m ² /hr to 140 l/m ² /hr. |

| DO-160 Sections | Changes from DO-160C to DO-160D ¹ | Changes from DO-160D ¹ to DO-160E | Changes from DO-160E to DO-160F |
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| | following exposure to this environment, not to verify the unit's ability to keep out water. | | |
| Section 11: Fluids Susceptibility | Table 11-1 eliminated reference to fire extinguishants and add additional de-icing fluid, propylene glycol. Aircraft fire extinguishants are gaseous and do not exist in liquid form under normal conditions. De-icing fluid added to reflect current industry practices. | Updated list of fluids and added inspection. | No changes were made. |
| Section 12: Sand and Dust | Editorial and clarifications changes only. | Sand and dust were separated into two categories. Update the mixtures to current commercial available characteristics. | Category definitions were revised for clarification. Additional sand concentrations were added. Size distributions and sum of total percentages to 100% were adjusted in Section 12.3.2. |
| Section 13: Fungus Resistance | Section 13.5.7 was revised to eliminate 48 hour period after removal from chamber before performance test. | Other causes of fungus other than nutrient materials and personnel safety caution were added. Test failure criteria were clarified. | Magnesium sulfate was adjusted to align with other ingredients. |
| Section 14: Salt Fog | Change functional test criteria. Functional test may now be performed following 48 hour dry-out period. | Title of section was changed from Salt Spray to Salt Fog. Category T was added for severe salt atmosphere. | Changed term Salt Spray to Salt Fog throughout this section. |
| Section 15: Magnetic Effect | Text was added to clarify source of referenced magnetic field. | Section 15.3 was modified to provide a more detailed test procedure than in previous versions, including a requirement to verify field uniformity if the compass must be moved to change the measurement distance to the EUT (equipment under test). The new Figure 15-1 provides a test setup diagram and gives notes on proper performance of the test. | A new Category Y was added for measurements made immediately adjacent to the unit under test. Descriptions of each equipment category were added to Section 15.1 <i>Purpose of Test</i> along with discussion of how the test results are used to determine how close the EUT may be installed to a compass or compass sensor. Text allowing the measurements to be made with an uncompensated compass or equivalent magnetic sensor was also added. |

| DO-160 Sections | Changes from DO-160C to DO-160D ¹ | Changes from DO-160D ¹ to DO-160E | Changes from DO-160E to DO-160F |
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| <p>Section 16: Power Input</p> | <p>Change 2 to DO-160D, published June 12, 2001, revised Section 16, by including new tests, and modifications to existing testing, to address the issues of AC harmonic current content and variable frequency AC power systems.</p> | <p>The entire section was re-ordered so that all the AC tests were in one subsection and all DC tests were in another subsection, making Section 16 easier to use and understand. DO-160E also introduced some new tests, such as a DC content test for AC powered equipment, and a new subsection covering "Load Equipment Influence on Aircraft Electrical Power Systems."</p> | <p>More tests are required for both AC and DC powered equipment. A 270V DC bus generated from the A (WF) AC power bus was added as Category D. Discrete step test methods were defined for AM and FM modulation on AC systems. AM voltage modulation on AC buses was increased. Double interrupt test methods were added for DC equipment. Manual reset was explicitly not permitted after single and double power interrupts. The dwell at 28V between the short and the long dc voltage surge was removed. Loss of phase testing was added for three phase. A Power Factor test designation was added for ac equipment. DC current draw tests from ac equipment current were added. In-rush and current modulation test designations were added for both ac and dc equipment. Tolerances were added to most tests. Category H, harmonic emissions, measurement methods were updated.</p> |
| <p>Section 17: Voltage Spike</p> | <p>Editorial changes were made to support document consistency. Reference to "DC only" condition was eliminated thereby expanding applicability to both AC and DC systems. Figures were modified to accommodate the inclusion of AC power systems. Reference to negative pulse generation network was eliminated.</p> | <p>No significant changes were made.</p> | <p>Section 17.4 <i>Test Procedures</i> was modified to clarify application of positive and negative transients over the specified period of time. Test conditions were clarified when multiple power pins are present.</p> |
| <p>Section 18: Audio Frequency Conducted Susceptibility-Power Inputs</p> | <p>DO-160C referenced Figures 16-4 and 16-5 for DC ripple test requirements; these figures were moved to Section 18 as Figures 18-2 and 18-3.</p> | <p>The equipment category designators A and J were eliminated, and categories R and K were added.</p> | <p>New test for 270V dc input differential ripple to follow same curve as 28V Category Z, but at 4 times the amplitude was added. A common mode noise test has been added for 270V Category Z equipment. For test equipment that generate a continuous linear frequency</p> |

| DO-160 Sections | Changes from DO-160C to DO-160D ¹ | Changes from DO-160D ¹ to DO-160E | Changes from DO-160E to DO-160F |
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| | | | sweep, the minimum (i.e., fastest) sweep rate has been slowed to make swept testing equivalent to stepped testing, especially at resonances. An optional DC blocking network is added to the test setup figures to prevent damage to the signal source. |
| Section 19: Induced Signal Susceptibility | Category C was added to include test levels that are appropriate for installations with long wire runs or minimum wire separation. The test levels for magnetic and electric fields induced into wiring were increased. | A second equipment category designator was added to indicate the AC power system operating frequency (Constant, Narrow Variable, or Wide Variable). The frequency scan rate was changed to 30 steps per decade, with a 10-second dwell time at each frequency. | Clarification to existing formula used to calculate test frequencies was made. |
| Section 20: Radio Frequency Susceptibility (Radiated and Conducted) | <p>The revisions to Section 20, in DO-160D Change No.1, published December 2000, include a new, Mode-Tuned, Reverberation Chamber Radiated RF Susceptibility test method. New categories (test levels) were also added to Section 20, including Category L, which requires Radiated RF Susceptibility testing (pulsed) as high as 7200 volts/meter.</p> <p>An alternate procedure was added for mode-stirred radiated susceptibility tests. The mode-stirred procedure was accepted as an alternate that may require lower-power amplifiers.</p> | A section providing guidance and caution related to RF power amplifier harmonics and their potential to affect the test results was added, along with a revision that allows the use of an oscilloscope to measure Conducted Susceptibility test levels. The Mode-Tuned test method for Radiated Susceptibility was modified to allow for the option of using the received power on the monitor antenna to determine the test level, as opposed the E-field readings from a 3-axis sensor. Flexibility in the number of tuner steps was also added, giving the user the choice of increasing the number of steps based on the need for greater field uniformity or a higher test level, or decreasing the number of tuner steps to decrease the test time. | Test categories were reduced and “alternative” modulations for Category R were eliminated. There is now only one test method for conducted susceptibility. Clarification has been added regarding the requirement to expose all apertures and openings of the EUT in anechoic chamber method. RTCA/DO-160F added requirements to test several additional dwell frequencies where the image frequencies for n =2 through 10. 160F removed the permissive language associated with these tests. It used to be “should” but 160F now uses “shall”. |

| DO-160 Sections | Changes from DO-160C to DO-160D ¹ | Changes from DO-160D ¹ to DO-160E | Changes from DO-160E to DO-160F |
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| <p>Section 21: Emission of Radio Frequency Energy</p> | <p>Change Category Z requirements to reflect need for additional scrutiny in the VHF COM NAV and GPS frequencies.</p> | <p>All of the figures were cleaned up and made easier to read. The Radiated Emissions limits for Categories M and H were modified slightly so that the notches that occur in various frequency ranges now have sloped bottoms to match the rest of the limit. The frequency range of the first notch has also been changed for a more precise match with the communications/navigation frequency range that the notch protects.</p> | <p>The conducted emissions frequency range has been broadened to 150 kHz - 152 MHz, and the Radiated Emissions test frequency range has been narrowed to 100 MHz - 6 GHz. A new procedure for radiated emissions measurements in a reverberation chamber was added. In the anechoic chamber method, clarification has been added regarding the requirement to expose all apertures and openings of the EUT. A new limit category has been added, Category P, to provide added protection for certain receivers by use of even deeper notches than previously used.</p> |
| <p>Section 22: Lightning Induced Transient Susceptibility</p> | <p>DO-160D Change No. 3, published December 2002, added additional waveform sets, cable bundle test levels, and the procedures for performing indirect lightning multiple stroke and multiple burst tests using the existing defined test waveforms. The category designations were modified to allow users to designate categories that indicated that these additional tests had been performed. New Waveform Set designators, G through K, were added to cover the Multiple Burst and Multiple Stroke tests. Another significant addition to Change 3 was setup information on performing pin injection tests with power applied. Several different setup diagrams were added to assist users in performing these tests properly. Improperly connecting the lightning generator to a pin with power applied could result in insufficient stress on the pin.</p> | <p>The DO-160E cable bundle test section was modified to include a new section providing guidance for performing cable bundle tests on bundles that normally contain shields, with the shields removed. This guidance allowed testing of a cable bundle at test levels currently defined in DO-160, but intended to demonstrate compliance to aircraft installation threats that are higher than these standardized levels. It explicitly stated that the test generator used for cable bundle testing does not need to be capable of producing the voltage or current limit level, provided that the current or voltage test level can be achieved on the cable under test.</p> | <p>Section 22 was restructured with additional test requirements moved from notes under figures to the main body of the document, and paragraphs were numbered to provide easy reference to the requirements contained in each paragraph. In the waveform set tables and the test level tables, both the voltage and the current waveform number are now shown to eliminate any ambiguities with how waveforms are related to each other. This section was modified to clarify when a test was successfully completed and when, in the case of reaching a limiting level before a test level, another waveform test was needed. The cable bundle section now contains a path to follow for every waveform set and criteria for acceptable and unacceptable test limit waveforms that leads the user to successful test completion regardless of the configuration of the cable under test.</p> |

| DO-160 Sections | Changes from DO-160C to DO-160D ¹ | Changes from DO-160D ¹ to DO-160E | Changes from DO-160E to DO-160F |
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| Section 23: Lightning Direct Effects | Additional procedure with associated electrode was provided for producing flashover when flashover is not produced during the normal procedure and it is desired that flashovers occur. | No significant changes were made. | Clarification of test waveforms and methods has been added throughout the section. Category designations have been added to separate voltage and current tests. Category designations have been clarified, and Category F has been deleted. |
| Section 24: Icing | Editorial and clarifications changes only. | No changes were made. | No major changes were made. Clarification of type of ice was incorporated. |
| Section 25: Electrostatic Discharge | A new section was added to address device level susceptibility issues for ESD. | No significant changes were made. | No significant changes were made, except correcting typographical errors in the figures. |
| Section 26: Fire, Flammability | | Section 26 was introduced in DO-160E. | No changes were made. |